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H03F 1/42

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(56) Documents cited
Demand-switched supply boosts amplifier efficiency, Leiner, Electronics November 9,1978 p115.

(58) Field of search
UK CL (Edition K) H3W WUB WUE WUP WUS
INT CL^5 H03F 1/02 1/42 1/44

(54) Controlling amplifier voltage to match impedance to output

(57) A radio transmitter consists of a number of power amplifier modules each comprising a power supply 3 and a power amplifying circuit 2 incorporating a power amplifying device e.g. FET 4. Imperfections in the matching of the FET 4 to the aerial impedance via an output matching network 6 is compensated for by varying the voltage of the power supply unit in inverse relation to the current demanded from the power supply unit.

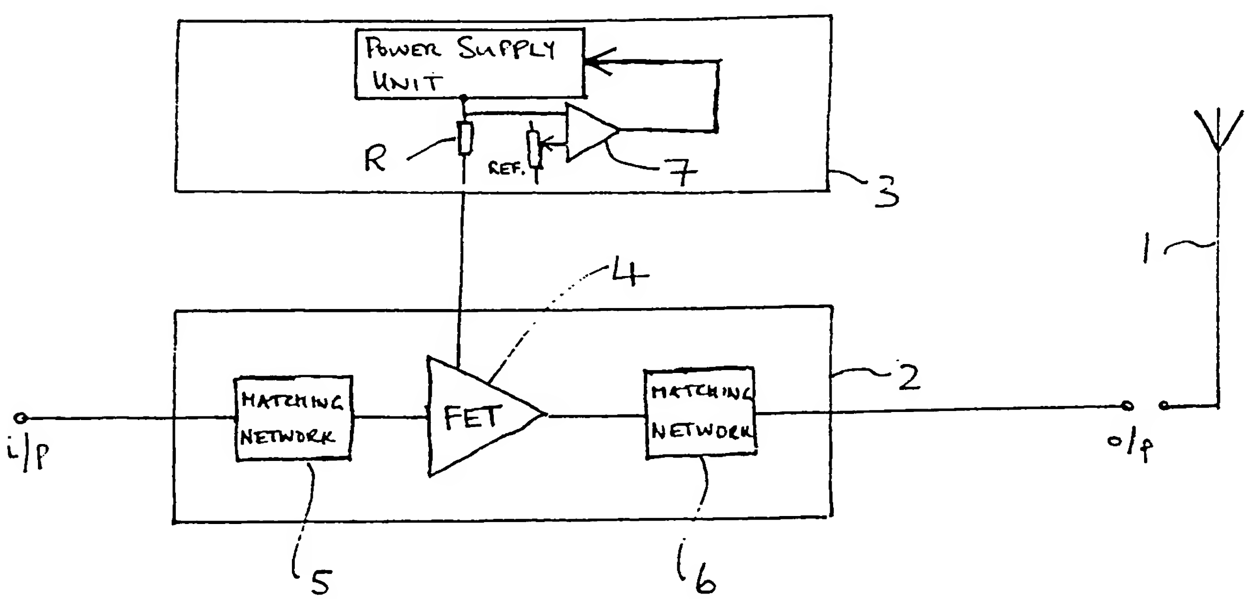

FIG. 1

GB 2 260 871 A

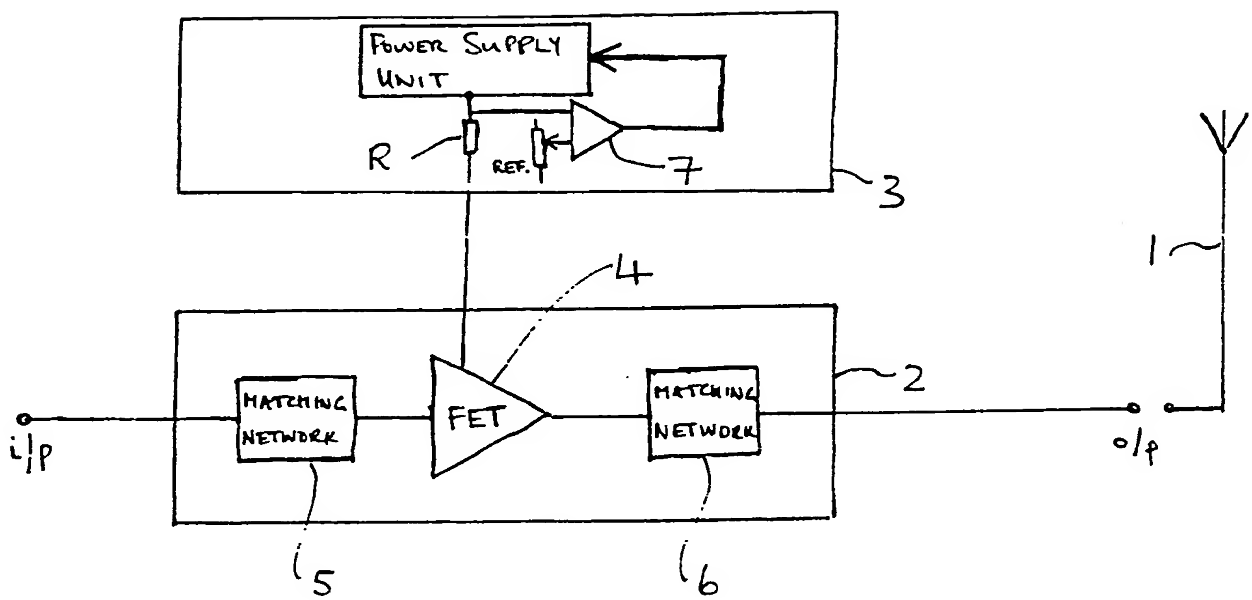
POWER SUPPLY UNIT
R
REF.
7
3
4
1
2
i/p
MATCHING NETWORK
FET
MATCHING NETWORK
o/p
5
6

Fig 1

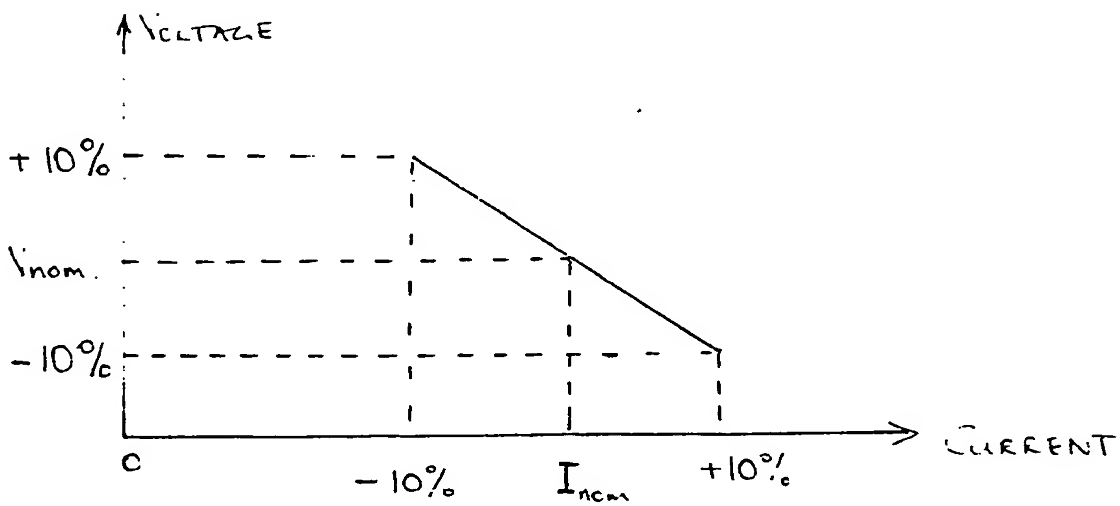
VOLTAGE
+10%
Vnom.
-10%
0
-10%
Inom
+10%
CURRENT

Fig 2

R.F. Power Amplifier

This invention relates to r.f. power amplifiers, especially for radio transmitters.

Typically the impedance presented to a transmitter by the aerial it is required to operate with, will deviate from the ideal impedance into which the transmitter will deliver optimum design performance. As a result, there may be a reduction in the specification achieved especially in relation to power gain and conversion efficiency.

This is especially noticeable in solid state power amplifiers compared to their valve equivalents because the former tend to be used to the limits of achievable power output for a given size of device.

Whilst an admittance centering unit can be employed to cancel out aerial mismatches, it is by nature a narrowband device and must be set up specifically at the operating frequency of the equipment.

The invention provides an r.f. power amplifier, comprising a semiconductor amplifying device, a power supply

for the semiconductor amplifying device, and control means for varying the supply voltage over a range of values in inverse relation to the current demand from the semiconductor amplifying device.

Instead of holding the power supply voltage constant as is usual for a regulator, it is varied in accordance with the invention to adjust the operating conditions of the semiconductor amplifying device in such a way as to reduce the adverse effects of mismatches: in particular efficiency is improved so the heating of semiconductor amplifying devices is reduced and also gain is improved by reducing the supply voltage when increased current is demanded, depending on phase and magnitude of the prevailing mismatch.

The invention is particularly applicable to semiconductor amplifying devices in the form of field effect transistors (FETs), operating in or near saturation.

A solid state broadcast transmitter, which includes an r.f. power amplifier constructed in accordance with the invention, will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a block schematic diagram of a power

amplifier module; and

Figure 2 is a graph showing the variation in voltage from the power supply.

The transmitter operates as a broadcast transmitter, and consists of a number of identical modules connected in parallel e.g. by the combiner shown in our co-pending patent publication number 2232028, (only one module being illustrated in the figure). The output of the combined modulators is connected to an antenna 1.

Each module consists of a power amplifier circuit 2 and a power supply unit 3.

The power amplifier circuit 2 employs a power FET 4 typically capable of providing 300w output power.

The input and output impedances of such power FETs are of the order of 1 or 2ohms, and so matching networks 5, 6 are provided for matching the impedances of the FET to the input i/p and the output o/p.

While the nominal impedance of antenna 1 is a pure resistive 50ohms, this is most closely approximated to in

practice at the centre of the range of frequencies of operation of the transmitter and the impedance may be either higher or lower at other points in the band of frequencies of operation, as well as being reactive. At worst, the voltage standing wave ratio (VSWR), which gives a measure of the mismatch, would be 1.5:1 at the ends of the band.

There is therefore no longer an ideal match presented via network 6 over the entire frequency range. With existing solid state transmitters, in which the power supply is a voltage regulator set to a fixed value, the result of this mismatch is operation at reduced efficiency at some frequencies, and reduced gain at other frequencies.

In accordance with the invention, the voltage of the power supply unit 3 is varied and alters the operating condition of the FET in such a way as to compensate at least partially for the mismatch.

Thus, the power supply voltage is varied in inverse linear relation to the current demanded by the FET. The voltage developed across resistor R which senses the current drawn from the power supply 3 is connected to one input of a comparator 7, the other input of which is supplied with the voltage which would be dropped across the resistor R if a

nominal current Inom was drawn from the power supply. Inom represents the maximum demand of the module when operating at its rated output power of 300 watts at the nominal supply voltage of e.g. 50 volt d.c. into an ideal i.e. 50 ohm load impedance. The output of the comparator provides a control signal for varying the voltage supplied to the FET. The regulation of the power supply voltage is over a predetermined range either side of nominal supply voltage.

Referring to Figure 2, experimental work has shown that where the current demand of the FET has increased above Inom, resulting in reduced efficiency and increased heating of the FET, the efficiency is retrieved and heating reduced by decreasing the voltage supplied by the same proportion (within the limits of $\pm$ 10% from Vnom and Inom). For example, where the current demand has increased by + 10% but the power supply is retained at its nominal voltage, the power dissipated in the FET is 300 watts, representing an efficiency of 50%. By reducing the power supply voltage by 10% the power dissipated in the FET falls to 200 watts representing a 60% efficiency figure. Similarly, if the gain of the FET is degraded by mismatch resulting in a reduction of current demand from the power supply unit, the gain can be retrieved by increasing the supply voltage by the same portion as the current has decreased (the r.f.

drive power may need to be as high as 9 watts representing a gain of 15dB when the power supply is operating at nominal voltage for the FET to be working at rated output power, but an increase of voltage produced by the power supply unit of 10% reduces the drive power required to 6 watts, representing a gain of 17dB).

The relation between the voltage of the power supply unit and the current demanded is shown as linear in Figure 2, but a non-linear inverse relation may be found suitable as well. In fact the performance approximates to supplying constant power over the variable voltage range, thus preventing the FET from drawing excessive power from the supply and dissipating heat.

Suitable FETs for the power amplifier modules are FET No. TP1940 supplied by Motorola and FET No. BLW278 supplied by Philips. Both are designed to deliver 300w output power. The invention is however applicable to other FETs of different output powers, and is also applicable to bipolar semiconductor amplifying devices.

Of course there is no need to have several power supply modules, and the invention is applicable to the situation where a single module is used.

The transmitter may be arranged for operation in VHF/FM band i.e. from 88 - 108 MHz, but the invention is applicable to other types of modulation and other frequency bands.

CLAIMS

1. An r.f. power amplifier comprising a semiconductor amplifying device, a power supply for the semiconductor amplifying device, and control means for varying the supply voltage over a range of values in inverse relation to the current demand from the semiconductor amplifying device.

2. An r.f. power amplifier as claimed in claim 1, in which the control means is arranged to vary the supply voltage in inverse linear relation to the current demand.

3. An r.f. power amplifier as claimed in claim 1, in which the control means is arranged to vary the supply voltage to supply constant power to the semiconductor amplifying device over the range of values.

4. An r.f. power amplifier as claimed in any one of claims 1 to 3, in which the semiconductor amplifying device is a FET.

5. An r.f. power amplifier as claimed in claim 4, in which the control means is arranged to vary the supply

voltage over a range of $\pm$ 10% from the nominal operating value of the the FET in response to a variation of $\pm$ 10% in the variation of current demand from the FET from a predetermined value.

6. An r.f. power amplifier as claimed in any one of claims 1 to 5, in which the amplifier consists of a number of identical modules, each employing a semiconductor amplifying device as claimed.

7. An r.f. power amplifier substantially as hereinbefore described with reference to the accompanying drawings.

8. A radio transmitter incorporating an r.f. power amplifier as claimed in any one of the preceding claims.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

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Relevant Technical fields

(i) UK Cl (Edition K) H3W (WUE,WUB,WUP,WUS)

(ii) Int Cl (Edition 5) H03F 1/02,1/42,1/44

Search Examiner
D MIDGLEY

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search
24 MARCH 1992

Documents considered relevant following a search in respect of claims 1-8

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	Demand-switched supply boosts amplifier efficiency, Leiner, Electronics November 9, 1978, page 115	

Category	Identity of document and relevant passages	Relevant to claim(s.

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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